Central Bank's Communication and Markets Reactions: Polish Evidence

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ABSTRACT:

Purpose:
This study contributes to the pool of knowledge about the impact of monetary policy communication of central banks on financial instruments' prices and assets' value in emerging markets.

Design/methodology/approach:
Empirical analysis is executed using the National Bank of Poland (NBP) announcements about its monetary policy covering the data from the broad financial market in its 3 main segments: stock market, foreign exchange market and bonds market. The reactions are measured relative to the changes in the NBP announcements and also with respect to investors' expectations. ARCH models with dummy variables are used as the main methodological tool.

Findings:
Bonds market and foreign exchange market are the most sensitive market segments, while interest rate and money supply are the most influential types of announcements. The changes of the revealed new macroeconomic figures had more impact on assets' prices movements than the deviations from their expectations. Moreover, greater diversity of the Monetary Policy Council (MPC) members' opinions on the voted motions, captured in the MPC voting reports, is associated with more cases of statistically significant NBP communication events.

Practical implications:
The findings have direct relevance for fund managers, portfolio analysts, investors and also for financial market regulators.

Originality/value:
The results provide novel evidence about how the emerging financial market responds to monetary policy announcements. They help understand the nature of the impact of public information on financial assets' valuation and on movements of their prices, analysed comprehensively in 3 market segments, in the emerging market environment.

Keywords: Central bank; Macroeconomic announcements; Monetary policy; Emerging financial market reactions; Asset prices returns; National Bank of Poland (NBP); Stock market; Foreign exchange market; Bonds market.

JEL classification: E5, F3, G1, O2, P3

1. Introduction

Central banks in emerging markets play an active role through their monetary policy actions and they may affect the valuation of assets by influencing the movements of financial market prices (see Bernanke and Kuttner (2005), Wongswan (2009) and Cieślak, Morse and Vissing-Jorgensen (2019), Tiberto, de Moraes and Corrêa (2020), Rai, Rojer and Edirel (2021), among others).

The impact of central banks on financial market is materialized as a result of their decisions to move interest rates or to change the value of other important macroeconomic variables, such as money supply etc. (see Hanousek, Kočenda and Kutan (2009), Hayo and Neuenkirch (2012), Sun (2020), Brubakk, Ter Ellen and Xu (2021), Breitenlechner, Gründler and Scharler (2021)). The channels of transmission include covered or uncovered interest rates parity relationships in the foreign exchange market, discounting of future cash flows mechanism in the bonds market or the changing dynamics of capital flows in the stock market, which may be triggered by the central banks' decisions (see Binder (2017), Weber (2019), Lamla and Vinogradov (2019), Hüning (2020), Bennani (2020), Beutel, Metiu and Stockerl (2021), among others).

Recent research, relying on the learning-to-forecast (LTF) experimental framework, has shown that simpler, more accessible, communication of central banks tends to be more effective and that its effects work through the mechanisms that promote public understanding of the central bank's goals and actions in the current economic context (Kryvtsov and Petersen (2021)). Also Bholat et al. (2019) argue, based on the results of a large-scale online experiment with a sample representative

of the UK population, that central banks' communicative techniques, which use more simplified language and make monetary policy messages relatable to people's lives, increase public comprehension and trust in monetary and macroeconomic policy decisions.[1]

In this study, we extensively investigate the impact of this type of central bank's communication in form of monetary policy announcements of the National Bank of Poland (NBP) regarding the key macroeconomic data, which it releases on regular basis. Our evidence comprehensively covers 3 market segments (stock market, foreign exchange market and bonds market).

Polish financial market is a particularly interesting case for analysing the central bank's communication and investors' reactions as an important and unique emerging market, because in spite of the European Union (EU) membership it has its own central bank, which conducts independent monetary policy (i.e. independent even from the European Central Bank, which is responsible for monetary policy for most of the EU countries). In addition, Poland maintained its own national currency, the Polish zloty (PLN), instead of adopting the Euro, which is an important tool in planning and executing broader macroeconomic policy. This institutional environment was formed as a result of political changes and economic reforms, including central bank development, which were initiated in the early 1990s. Since the 2000s, the National Bank of Poland has been following the principle of conducting a regular and transparent communication policy with financial markets by publishing a range of macroeconomic data (most of which is announced on monthly basis) regarding its monetary policy variables.

Regarding the size, Poland has also the biggest economy and the largest financial market in the Central and Eastern Europe (CEE) region. Its foreign exchange market has been in the past two decades about twice as large as the next two markets

in the Czech Republic and in Hungary (see Triennial Central Bank Survey (2019) and the earlier BIS triennial surveys). The Polish stock market is also the biggest in the region. The Warsaw Stock Exchange (WSE) is the largest stock market in the CEE with a lot of initial public offerings (IPOs) activity.[2] Moreover, the bonds market in Poland is one of the largest in the CEE region. Already in 2012 it was the second biggest one in the broader central Europe region (after Vienna bond market in Austria) in terms of the number of the introduced bonds series.[3]

Last but not least, Poland is often used as an example of successful economic transformation. Emerging markets around the world differ substantially in terms of their institutional characteristics, including such issues as existence of institutional voids, the relative importance of informal *versus* formal institutions as well as the institutional changes and transitions (Rottig D. (2016)), but also regarding broader macroeconomic benefits of financial development, the role of institutional quality and, in particular, such key feature as central bank's independence (see e.g. Agoba et al. (2019) or (2021). However, it is argued that Poland's experience in building successful institutions (which includes an independent central bank: the National Bank of Poland), as well as mitigating major institutional voids, can serve as a positive lesson for other countries and it can be instructive for other emerging markets, which are on a similar road to restructuring their economic systems (see e.g. Puffer, McCarthy and Jaeger (2016)).

Overall, our evidence from Poland may, therefore, provide important lessons for other emerging markets that went through (or are currently going through) fundamental economic reforms and which switched to a market economy.[4]

We deal with the investigation of the reaction of assets' returns in the 3 most important market segments and we measure the effects of the NBP communication on the key instruments from the foreign exchange market, bonds market and stock market. Our research contributes to understanding how monetary transmission

channels operate in emerging markets economies, which implemented major institutional reforms. Furthermore, our results may also lead to better understanding of the monetary policy decisions of central banks, which should be helpful in construction of new theoretical models in finance.

We show that the bonds and foreign exchange markets are more sensitive to central bank communication than the stock market, and that interest rate and money supply data are the most influential announcements, which has also direct implications for investment strategies. These findings are, therefore, relevant for the financial industry, because they may aid decision-making processes of fund managers, portfolio analysts and investors.

Moreover, we also investigated the Monetary Policy Council voting patterns related to different MPCs terms in office and we show that they matter from the point of view of the intensity of markets reactions. The varying degree of diversity of the MPC members' opinions, captured by the views dispersion measure, allowed us further to assess the change in the effectiveness of the Polish central bank's communication.

Overall, our study contributes to the empirical academic literature on the mechanisms of transmission of monetary policy to asset prices and on the role of central bank's communication in 3 different asset markets.

The uniqueness of the contribution of our results relies also on a combination of a very broad range of data from 3 market segments, the intra-daily data frequency and the results which link the findings about the markets reactions with the Monetary Policy Councils terms in office. All three aspects are very rarely analysed in the literature and, in particular, the use of very high frequency data (we exploit in this study the data at 1-minute frequency of observations) is unique in emerging markets research (notable exceptions include earlier paper by Hanousek, Kočenda and Kutan (2009)).

The remainder of this paper is organized as follows. Section 2 provides a literature review about the impact of public announcements on financial markets with a focus on the emerging markets. Section 3 describes the data, section 4 discusses methodology and section 5 reports estimation results from models from all 3 market segments and investigates the relevance of the Monetary Policy Council terms in office with a focus on the MPC members' voting patterns. In section 6 we present a simulation of a trading strategy in the out–of–sample period relying on the in–sample estimates. Section 7 provides a discussion, while the last section 8 offers conclusions and points towards possible policy implications of the main findings from this study for other emerging markets.

2. Literature Review

Central banks' communication, and its impact on financial market, has been analysed for developed countries in numerous papers using typically the data from the US and the European Union relying mainly on the Federal Reserve Board (FED) and the European Central Bank (ECB) monetary policy decisions (see the evidence published in Bernanke and Kuttner (2005), Wongswan (2009), Hausman and Wongswan (2011), Bekaert, Hoerova and Lo Duca (2013), Lucca and Moench (2015) and more recently in Cieślak, Morse and Vissing-Jorgensen (2019), among many others).[5]

However, the available studies on the role of central banks' public announcements, and their influence on asset returns in emerging markets countries, are still scarce.[6] Majority of them focus on stock markets (see Ganapolsky and Schmuckler (2001), Robitaille and Roush (2006), Hanousek, Kočenda and Kutan (2009) or Anwer, Azmi and Ramadili (2019), among others), while substantially fewer

extant papers concern the investigations of other market segments (such as Serwa (2006), Büttner and Hayo (2012), Su, Ahmad and Wood (2020) and Sun (2020), who analysed interest rates and money market instruments, Andritzky, Bannister and Tamirisa (2007), who examined bonds market, or Frömmel, Han and Gysegem (2015) and Brzeszczyński and Kutan (2015), who investigated foreign exchange market). Empirical evidence from those studies points towards the existence of statistically significant reactions to the central banks' communication, although the reported effects vary across markets segments and instruments.[7]

Regarding the research in this field specifically for Poland using the data about macroeconomic announcements, previous publications include Ziarko–Siwek (2004), Janecki (2012), Gurgul et al. (2012), Kubacki (2014), Kapuściński et al. (2014), Będowska–Sójka (2016) and Baranowski and Gajewski (2016), among others.

In the earlier study related directly to this paper, Brzeszczyński, Gajdka and Kutan (2017) analysed the reaction of the Polish market to the NBP central bank's announcements, however the focus and scope of that research, the numbers of the NBP announcements and the instruments covered, sample periods (differing by nearly one decade) as well as the applied methods (we provide a very broad extension of the in-sample models estimations), in comparison to our current work are very different. However, our paper is much different and provides a substantial extension of this previous research. The study by Brzeszczyński, Gajdka and Kutan (2017) modelled only 2 instruments: one instrument from stock market (WIG index) and one instrument from the foreign exchange market (USD/PLN currency exchange rate), while we comprehensively investigate 12 instruments from 3 market segments (including bonds market, which was not considered at all in the Brzeszczyński, Gajdka and Kutan (2017) paper). Moreover, the range of the analysed announcements is different and so is also the overall focus of the conducted research, because Brzeszczyński, Gajdka and

Kutan (2017) concentrated on the analysis of changes in the trading activity (volume of trade and bid-ask spread variables) and on returns, while we focus on returns and, more importantly, on the types of changes of the central bank's announcements (i.e. direction of change of the announced new figures, changes with respect to market expectations etc.) rather than on just simple dates of these events. Brzeszczyński, Gajdka and Kutan (2017) did not consider either any out-of-sample analysis, while we in this paper simulate an entire trading strategy in the out-of-sample period based on the in-sample estimates from the ARCH models. Last but not least, we also investigate in this current paper the relevance of the Monetary Policy Council terms in office, along with the voting patterns among its members, which is another contribution and important difference in comparison with the earlier study by Brzeszczyński, Gajdka and Kutan (2017).

Our paper provides, therefore, a substantial extension of the work presented in the paper by Brzeszczyński, Gajdka and Kutan (2017), which extensively demonstrates the economic significance of the estimation results from respective models by relying on the construction and simulation of an investment strategy using intra-daily data in the out-of-sample period until the year 2020.

There also exist very few, yet particularly interesting, studies, which investigate the impact of the verbal communication of the prominent policymakers on financial markets. For example, Gertler and Horvath (2018) analysed the European Central Bank's Governing Council (GC) members' public statements (speeches, conference discussions and media interviews) between GC meetings and examined a pattern of market responses to such *ad hoc* communication of those key ECB policy makers. Schmeling and Wagner (2019) further examined the tone of the ECB communication based on the transcripts of the ECB press conferences. A notable example in this stream of literature dealing with emerging markets is the earlier paper by Rozkrut et al.

(2007), which presents the analysis of the statements related to future monetary policy decisions (verbal statements reported by major news agencies and official communiqués of the central banks) and their link with the movements of the foreign exchange rates in the 3 largest CEE countries: the Czech Republic, Hungary and Poland.[8]

In summary, the available research on emerging markets, especially those from the EU countries, is still limited and the existing literature reports predominantly the results using the data from stock markets.[9] Our study extends, therefore, the current literature by providing new empirical evidence from Poland and using in one compact study a comprehensive dataset from 3 market segments: stock market, foreign exchange market and bonds market.

3. Data

The data sample used in our study covers over 10 years from 6th November 2009 to 15th February 2020. The starting point in this period is the earliest time for which all the NBP announcements, as well as most of their respective expectations data, were available, so this is the longest data sample possible to investigate in this case. The frequency of data in our database is daily. The in–sample estimation period ends on 24th May 2019 and it includes a total of 2491 observations. The out–of–sample analysis further covers the period from 25th May 2019 to 15th February 2020.

We constructed models for 12 financial instruments from 3 most important market segments on the broader financial market in Poland: stock market (stock indices: WIG, WIG20 and sWIG80)[10], foreign exchange market (currency exchange rates: USD/PLN, EUR/PLN, GBP/PLN, CHF/PLN and JPY/PLN)[11] and bonds market (1 year bonds, 2 years bonds, 5 years bonds and 10 years bonds).

In this study, we used the following announcements made on the regular basis by the National Bank of Poland informing about the release of its new monetary policy data: (1) interest rate, (2) money supply M3, (3) current account data and (4) official reserves.

We captured the NBP announcements by constructing relevant dummy variables for the days when the particular news release events occurred.

The interest rates dummy variables are coded for the four following situations: when there was an increase or decrease of the interest rate and when the announced new interest rate was above or below the market expectations. The market expectations were measured using the data reported by Bloomberg.

Similarly, we define corresponding variables for the M3 money supply for the cases when the new M3 value increased or decreased and when its new value was above or below the market expectations and we use exactly the same definitions for the current account data in all four instances.

In case of the official reserves, we could define only two dummy variables, i.e. when the value of the new official reserves data increased or decreased, because there were no market expectations available for this macroeconomic category, so we could not code the dummy variables for the deviations from the levels anticipated by the market.

As mentioned earlier, across all the NBP announcements described above, during the entire period of our analysis there were 450 events, which are composed of the following numbers of news released for the individual dummy variables: 105 for interest rates, 115 for money supply, 115 for current account and also 115 for official reserves.

A detailed summary of the variables, which we used in our models, is presented in Table 1.

Table 1. Summary of dependent variables, control variables and independent variables used in all models

Dependent variable	Description	Control variable	Description
Bonds Market Models:			
10 years bond yield	Rate of return of Polish government 10 years bonds	Global bonds return	Barclays Global Aggregate Total Return Index (in USD)
1 year bond yield	Rate of return of Polish government 1 year bonds		
2 years bond yield	Rate of return of Polish government 2 years bonds		
5 years bond yield	Rate of return of Polish government 5 years bonds		
Foreign Exchange Market Models:			
Dependent variable	**Description**	**Control variable**	**Description**
CHF/PLN exchange rate return	Rate of return of CHF/PLN exchange rate	CHF basket	Rate of return of basket of global currencies measured against CHF
EUR/PLN exchange rate return	Rate of return of EUR/PLN exchange rate	EUR basket	Rate of return of basket of global currencies measured against EUR
GBP/PLN exchange rate return	Rate of return of GBP/PLN exchange rate	GBP basket	Rate of return of basket of global currencies measured against GBP
JPY/PLN exchange rate return	Rate of return of JPY/PLN exchange rate	JPY basket	Rate of return of basket of global currencies measured against JPY
USDPLN exchange rate return	Rate of return of USD/PLN exchange rate	USD basket	Rate of return of basket of global currencies measured against USD
Stock Market Models:			
Dependent variable	**Description**	**Control variable**	**Description**
sWIG80 index return	Rate of return of sWIG80 stock index from WSE	MSCI World Index return	Rate of return of MSCI World Index
WIG index return	Rate of return of WIG stock index from WSE		
WIG20 index return	Rate of return of WIG20 stock index from WSE		
Independent variables		**Description**	
Interest rate above expectations		NBP's interest rate above market expectation	
Interest rate below expectations		NBP's interest rate below market expectation	
Increase of interest rate		Increase of NBP's interest rate	
Decrease of interest rate		Decrease of NBP's interest rate	
Money supply (M3) above expectations		M3 money supply above market expectations	
Money supply (M3) below expectations		M3 money supply below market expectations	
Increase of money supply (M3)		Increase of M3 money supply	
Decrease of money supply (M3)		Decrease of M3 money supply	
Current account above expectations		Current account value above market expectations	
Current account below expectations		Current account value below market expectations	
Increase of current account		Increase of current account value	
Decrease of current account		Decrease of current account value	
Increase of official reserves		Increase of international reserves	
Decrease of official reserves		Decrease of international reserves	

The frequency of the NBP announcements is monthly and their more specific timings are as follows: money supply (M3) is released usually between 12th and 14th calendar day of every month, official reserves are published typically between 5th and 7th calendar day of every month, while current account data is revealed in the middle of every month. Interest rate announcements are made following the decisions of the Monetary Policy Council after its meetings (which are held on different days of the respective months).

Table 2. NBP interest rate and other macroeconomic data announcements relative to market expectations in the period from 6th November 2009 to 24th May 2019

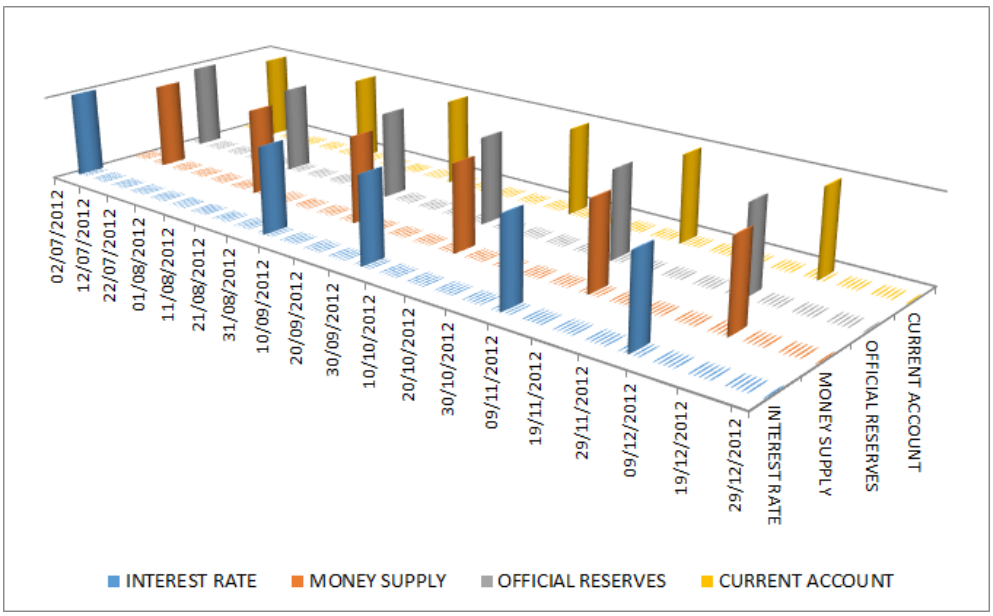
	Interest rate	Money Supply (M3)	Current Account	Official Reserves
	Number of announcements:			
Total number of changes	15	112	113	115
Change upwards	5	63	62	63
Change downwards	10	49	51	52
Change the same as expected by the market	7	7	28	–
Change higher than expected by the market ('positive surprise')	4	52	43	–
Change lower than expected by the market ('negative surprise')	4	53	43	–

Table 2 reports further the NBP data (interest rate and other macroeconomic data announcements) presented relative to market expectations, while Figure 1 depicts a sample of all four NBP announcements. It illustrates their frequency and shows their

regular distribution across time for two selected quarters of the year (i.e. Q3 and Q4 2012 chosen as an example).

Two main sources of data, which we exploited for the construction of our database, are as follows: (1) National Bank of Poland (data about the NBP announcements dates and the values of the newly revealed interest rates and other relevant macroeconomic figures) and (2) Bloomberg (data about prices from the foreign exchange market, stock market and bonds market segments).

Figure 1. Distribution of the NBP announcements
in the example period of two quarters (Q3 and Q4 in the year 2012)



Note: Figure 1 illustrates the regularity in the pattern of all four NBP announcements used in this study. The interest rate, money supply M3, current account data and official reserves are published at monthly frequency, so there are 12 releases every year for all of them except only for the interest rate, for which there are 11 announcements made annually, because one meeting of the NBP monetary policy council in summer is skipped (typically in August due to summer holidays period). Therefore, Figure 1 which covers as an example two quarters of the year (i.e. Q3 and Q4 in the year 2012) shows 6 announcements for the money supply M3, current account data and official reserves and only 5 announcements for the interest rate.

We used in our models the foreign exchange rates quoted on the international interbank currency market, which are reported in the Bloomberg database. The data

for the stock market indices and bonds prices available in Bloomberg are originally sourced from the Warsaw Stock Exchange, where these instruments are traded.

In the next section we describe and discuss our methodology.

4. Methodology

We focus comprehensively on the analysis of 3 market segments and we investigate their reactions to the release of key announcements of the National Bank of Poland. Because strong ARCH effects were detected, we exploited GARCH methodology (Engle (1982) and Bollerslev (1986)) as our modeling tool.

We estimated the following GARCH(S,Q) models to capture the effects of the NBP communication in the returns of all 12 instruments from all 3 market segments:

$$r_t^i = \beta_0 + \sum_{j=1}^{J}\sum_{k=1}^{K}\left(\beta_{j,k} D_{t-k}^j + \gamma_{j,k} Contr_{t-k}^i\right) + \varepsilon_t^i \tag{1}$$

$$h_t = \gamma_0 + \sum_{s=1}^{S}\gamma_s \xi_{t-s}^2 + \sum_{q=1}^{Q}\phi_q h_{t-q} \tag{2}$$

where $S > 0$, $Q \geq 0$, $\gamma_0 > 0$, $\gamma_s \geq 0$ and $\phi_q \geq 0$ and:

r_t^i – is daily rate of return from i–th financial instrument,

D_{t-k}^j – is the dummy variable taking on the value of 1 when the given j–th macroeconomic announcement was made and 0 otherwise.

The number of types of macroeconomic announcements is denoted by J. The types of these new announcements are: interest rate, money supply, current account and official reserves.

As discussed in the previous section, which described the data, for the first three types we distinguish four sub–types: above, below, up and down. In case of official reserves only the data regarding increase/decrease was available. Therefore, J is different for some variables, i.e. for the interest rate, M3 money supply and current account $J = 4$ and for official reserves $J = 2$.

The lag or the lead of each j–th macroeconomic news announcement is denoted by K. As we are focused on the analysis of the short–term reactions, in the estimations of our models the maximum lag is equal to -3 and maximum lead equal to +3 days.

Every i–th equation includes also the control variables $Contr$. In case of the models for the bonds, the control variable is the Bloomberg Barclays Global Aggregate Total Return Index as the global bond market indicator. For the stock market models, we adopted MSCI World Index as the commonly used measure of the global stock market movements. In the foreign exchange market models, we used the Bloomberg's baskets of global currencies measured against respective currency (EUR, USD, CHF, GBP or JPY). The control variables for all models are summarized in Table 1. [12]

We estimated the coefficients β_0, $\beta_{j,k}$ and $\gamma_{j,k}$ from equation (1) for every i–th financial instrument in our data sample. The focus of our investigation and further discussions in this study are the dummy variables parameters' estimates: $\beta_{j,k}$.

In cases when there was persistent heteroscedasticity, we applied higher orders of GARCH specification than GARCH(1,1), such as GARCH(2,1), GARCH(1,2), GARCH(2,2) etc. We also investigated the existence of the asymmetric effects by testing different alternative specifications (including EGARCH, GJR-GARCH etc.). If in any of the models there was autocorrelation detected, we eliminated it by adding the AR and/or MA terms.

The ARCH and autocorrelation statistics for all 12 variables are depicted in Table 3.

Table 3. ARCH and autocorrelation statistics

	Q10	Obs * R–squared	Prob. Chi–Square(10)
1 year bond yield	0.21	4.44	0.93
2 years bond yield	0.19	6.61	0.76
5 years bond yield	0.68	10.23	0.42
10 years bond yield	0.86	12.58	0.25
CHF/PLN exchange rate return	0.60	14.06	0.17
EUR/PLN exchange rate return	0.39	15.63	0.11
GBP/PLN exchange rate return	0.49	9.96	0.44
JPY/PLN exchange rate return	0.36	9.15	0.52
USDPLN exchange rate return	0.23	7.56	0.67
WIG index return	0.90	15.52	0.11
WIG20 index return	0.31	14.21	0.16
sWIG80 index return	0.38	11.84	0.30

Note: Each row represents error term statistics for each of the 12 models defined by equation (1).

Next section presents the estimation results from models (1) – (2) for all 12 instruments.

5. Empirical Results

5.1. Markets Reactions to the NBP Announcements

Tables 4 – 8 report comprehensively the estimation results for all 3 market segments covering all 12 instruments for $k = 0$ (i.e. no lead and no lag of the dummy variables) and also for $k = -2, -1, +1, +2$ (representing the respective lags and leads of +/- 1 day and +/- 2 days). Overall, there are 65 cases of statistically significant dummy variables estimates detected across all Tables 4 – 8.

The most responsive instruments were bonds (33 cases of statistically significant dummies) followed closely by foreign exchange rates (28 cases of statistically significant dummies) and then stock indices (only 4 cases of statistically significant dummies).

In terms of timing, there appear to be far more instances of statistically significant reactions before the announcement day (a total of 36 cases for both $k = -2$ and $k = -1$) than after the announcement day (a total of only 15 cases for both $k = +1$ and $k = +2$). On the announcement day, i.e. for $k = 0$, there were 14 cases of statistically significant estimates of dummy variables.

More specifically, Table 4 shows that for simultaneous relationship for $k = 0$, the most responsive market segment by far was the bonds market (11 cases out of 14 cases of statistically significant estimates in the entire Table 4), followed by the foreign exchange market and the stock market (only 2 and 1 cases, respectively). Estimates in the bonds models are also the strongest in terms of the level of statistical significance (i.e. in all instances at 1% and 5% level contrary to the models of stock indices and currency exchange rates where significance was found mainly at the weaker 10% level). Regarding the type of news, there is a dominance of interest rates' announcements evident in Table 4 (with 9 cases of statistically significant estimates). The next two most important announcements were official reserves data and M3 money supply (albeit with just 3 and 2 cases, respectively).

Table 5 presents the corresponding estimates for dummy variables from the models with the lag $k = -1$. Out of 23 statistically significant results, there are 11 and 10 cases in bonds market and foreign exchange market segments, respectively, and only 2 cases in the stock market segment. The most important type of announcement appears to be interest rate (with 11 statistically significant cases) followed by M3 money supply (with further 8 statistically significant estimates).

Table 4. Values of coefficients $\beta_{j,k=0}$ from equation (1), for $k = 0$ (i.e. no lead and no lag)

$k = 0$ (i.e. no lead and no lag)	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return
Interest rate above expectations	0.0058	0.0153	0.0223***	0.0054	0.0008	-0.0007	0.0003	-0.0016	-0.0013	-0.0025	-0.0042	-0.0058
Interest rate below expectations	-0.0157**	-0.0514***	-0.032***	-0.0187**	-0.0019	0.0009	-0.0010	0.0015	-0.0003	0.0039	-0.0000	0.0002
Increase of interest rate	-0.0092**	-0.0050	-0.0107	-0.0076***	0.0005	-0.0009	-0.0020	0.0014	-0.0026	0.0019	0.0002	-0.0002
Decrease of interest rate	-0.0004	0.0109**	0.0112***	-0.0017	0.0023	0.0004	0.0013	0.0004	0.0016	-0.0015	0.0001	-0.0002
Money supply (M3) above expectations	-0.0001	-0.0074	-0.0048	-0.0004	0.0031	0.0005	0.0039**	0.0019	0.0027	-0.0015	0.0019	0.0016
Money supply (M3) below expectations	0.0012	0.0068	-0.0020	0.0010	0.0035*	0.0012	0.0020	0.0016	0.0021	-0.0018	0.0011	0.0009
Increase of money supply (M3)	0.0004	0.0042	-0.0004	-0.0007	-0.0028	-0.0006	-0.0022	-0.0020	-0.0021	0.0018	-0.0010	-0.0000
Decrease of money supply (M3)	-0.0005	-0.0023	0.0001	-0.0006	-0.0021	-0.0001	-0.0011	-0.0009	-0.0013	0.0015	-0.0002	-0.0001
Current account above expectations	0.0016	-0.0024	0.0019	0.0008	-0.0001	0.0004	-0.0014	-0.0005	-0.0022	-0.0017	0.0034	0.0047
Current account below expectations	0.0006	-0.0009	0.0012	0.0031	0.0003	0.0007	0.0004	-0.0002	-0.0003	0.0015	0.0035	0.0033
Increase of current account	-0.0010	0.0049	-0.0019	-0.0011	-0.0013	-0.0011	-0.0003	-0.0007	0.0000	0.0010	-0.0034	-0.0038
Decrease of current account	-0.0015	0.0003	-0.0017	-0.0037	0.0001	-0.0001	-0.0002	0.0008	0.0001	-0.0001	-0.0020	-0.0024
Increase of official reserves	-0.0002	0.0008	-0.0007	-0.0005	-0.0004	-0.0003	-0.0006	0.0000	-0.0007	-0.0002	0.0003	-0.0000
Decrease of official reserves	-0.0028**	-0.0023	-0.0009	-0.0032**	0.0004	0.0005	-0.0004	0.0002	-0.0001	-0.0016*	-0.0012	-0.0012

Note: *** – denotes statistical significance at 1% level, ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

Table 5. Values of coefficients $\beta_{j,k=-1}$ from equation (1), for $k = -1$ (representing 1 day lag)

k = -1 (i.e. 1 day lag)	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return
Interest rate above expectations	0.0032	0.0206***	0.0025	0.0086	0.0008	-0.0002	-0.0005	0.0031	-0.0009	-0.0043	-0.0050	-0.0065
Interest rate below expectations	-0.0048	-0.0199*	-0.0477***	-0.0267**	-0.0047	-0.0030	-0.0047	-0.0074**	-0.0061	0.0012	0.0008	0.0003
Increase of interest rate	-0.0038	-0.0093	0.0011	-0.0019	-0.0033	-0.0012	-0.0045**	-0.0022	-0.0030	0.0012	0.0011	0.0008
Decrease of interest rate	0.0010	0.0090	0.0159***	0.0127***	0.0029*	0.0014	0.0032**	0.0047*	0.0022	0.0020	0.0040	0.0039
Money supply (M3) above expectations	0.0011	-0.0081	0.0018	-0.0020	0.0022*	0.0003	0.0029*	0.0036**	0.0036*	-0.0006	-0.0026	-0.0044*
Money supply (M3) below expectations	0.0047*	-0.0042	0.0073*	0.0024	0.0020	0.0010	0.0028	0.0022	0.0030	-0.0017	-0.0020	-0.0040
Increase of money supply (M3)	-0.0030	0.0049	-0.0057	-0.0024	-0.0008	0.0004	-0.0016	-0.0011	-0.0013	0.0005	0.0022	0.0032
Decrease of money supply (M3)	-0.0031	0.0026	-0.0036	-0.0008	-0.0010	0.0002	-0.0021	-0.0018	-0.0015	0.0004	0.0030	0.0050*
Current account above expectations	0.0036	0.0029	0.0004	0.0076**	-0.0010	0.0005	0.0018*	-0.0014	0.0013	0.0001	0.0005	-0.0005
Current account below expectations	0.0002	0.0047	0.0007	0.0005	-0.0008	-0.0002	-0.0002	-0.0005	-0.0003	-0.0002	0.0004	0.0007
Increase of current account	-0.0041*	0.0018	0.0025	-0.0017	0.0004	-0.0009	-0.0005	0.0009	0.0002	-0.0012	-0.0011	-0.0004
Decrease of current account	-0.0014	0.0000	-0.0003	-0.0019	0.0000	-0.0005	-0.0006	0.0001	-0.0006	0.0002	0.0003	0.0005
Increase of official reserves	-0.0015	0.0008	0.0007	-0.0011	-0.0006	-0.0003	-0.0005	-0.0007	-0.0004	0.0000	-0.0014	-0.0016
Decrease of official reserves	0.0000	0.0011	-0.0022	-0.0028*	0.0005	-0.0002	-0.0003	0.0002	-0.0004	-0.0012	-0.0000	0.0002

Note: *** – denotes statistical significance at 1% level, ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

Table 6. Values of coefficients $\beta_{j,k=1}$ from equation (1), for $k = +1$ (representing 1 day lead)

$k = +1$ (i.e. 1 day lead)	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return
Interest rate above expectations	0.0020	-0.0071	0.0114**	0.0048	-0.0013	0.0004	-0.0012	0.0025	-0.0018	0.0020	-0.0023	-0.0036
Interest rate below expectations	0.0177	0.0097	0.0089	0.0195	0.0011	0.0007	0.0023	-0.0017	0.0015	-0.0017	-0.0032	-0.0036
Increase of interest rate	0.0010	0.0092	0.0070	0.0041	0.0005	-0.0008	0.0001	-0.0015	0.0001	0.0004	0.0048	0.0072
Decrease of interest rate	-0.0038	-0.0106*	-0.0074	-0.0067	-0.0022	-0.0007	-0.0026	-0.0015	-0.0018	-0.0005	0.0019	0.0023
Money supply (M3) above expectations	-0.0025	0.0016	-0.0008	-0.0039	0.0001	-0.0004	-0.0023	-0.0001	0.0003	-0.0012	0.0001	-0.0000
Money supply (M3) below expectations	-0.0010	0.0055	0.0030	-0.0008	0.0002	-0.0003	-0.0010	0.0014	0.0013	-0.0010	-0.0009	-0.0019
Increase of money supply (M3)	0.0047*	-0.0009	0.0019	0.0065***	0.0002	0.0006	0.0016	-0.0004	0.0000	0.0015	0.0010	0.0022
Decrease of money supply (M3)	0.0018	-0.0040	-0.0012	-0.0010	-0.0004	0.0002	0.0000	-0.0015	-0.0012	0.0004	0.0011	0.0019
Current account above expectations	0.0014	-0.0053	0.0025	-0.0014	-0.0018	-0.0016**	-0.0018	-0.0020	0.0003	-0.0014	-0.0017	-0.0028
Current account below expectations	-0.0001	-0.0043	-0.0003	-0.0024	-0.002*	-0.0006	-0.0022	-0.0015	-0.0018	-0.0002	-0.0000	-0.0005
Increase of current account	-0.0036	0.0029	-0.0015	-0.0006	0.0022**	0.0014**	0.0018	0.0021	0.0014	0.0003	0.0015	0.0017
Decrease of current account	-0.0022	0.0043	-0.0017	0.0003	0.0017	0.0008	0.0019	0.0022	0.0015	0.0016	-0.0008	-0.0018
Increase of official reserves	0.0010	0.0023	0.0026	0.0005	-0.0002	0.0001	-0.0004	-0.0003	-0.0000	-0.0004	0.0009	0.0013
Decrease of official reserves	-0.0018	0.0010	-0.0020	-0.0016	0.0002	-0.0001	0.0007	-0.0002	0.0002	-0.0009	-0.0012	-0.0014

Note: *** – denotes statistical significance at 1% level, ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

Table 7. Values of coefficients $\beta_{j,k=-2}$ from equation (1), for $k = -2$ (representing 2 days lag)

$k = -2$ (i.e. 2 days lag)	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return
Interest rate above expectations	0.0000	0.0119	0.0032	-0.0015	0.0011	0.0025	0.0013	-0.0006	0.0029	0.0014	0.0026	0.0031
Interest rate below expectations	0.0079	-0.0013	0.0007	0.0262***	0.0041	0.0020	0.0055*	0.0109***	0.0058	0.0014	0.0054	0.0054
Increase of interest rate	0.0001	-0.0106	-0.0024	0.0042*	0.0020	0.0011	0.0028	-0.0004	0.0021	-0.0008	0.0003	0.0005
Decrease of interest rate	-0.0075*	-0.0021	0.0010	-0.0075**	-0.0038*	-0.0024	-0.0051***	-0.0058***	-0.0060***	0.0019	-0.0028	-0.0029
Money supply (M3) above expectations	0.0023	0.0073	0.0029	0.0014	0.0005	0.0006	-0.0012	0.0001	-0.0019	-0.0005	-0.0011	-0.0017
Money supply (M3) below expectations	0.0044**	0.0024	0.0012	0.0015	-0.0011	0.0002	-0.0024**	-0.0006	-0.0009	0.0011	0.0019	0.0022
Increase of money supply (M3)	-0.0014	-0.0067	-0.0001	-0.0011	-0.0004	-0.0010	0.0009	-0.0012	0.0007	-0.0004	0.0009	0.0013
Decrease of money supply (M3)	-0.0018	-0.0018	0.0004	0.0002	0.0002	-0.0005	0.0007	-0.0004	-0.0007	-0.0021	-0.0040	-0.0045
Current account above expectations	-0.0018	0.0017	-0.0016	0.0013	-0.0006	0.0001	-0.0005	0.0008	-0.0006	0.0007	0.0005	0.0000
Current account below expectations	0.0000	0.0019	0.0006	0.0035	0.0004	0.0009	0.0004	0.0006	-0.0005	0.0005	-0.0016	-0.0025
Increase of current account	0.0011	-0.0012	0.0045	-0.0008	0.0002	-0.0003	0.0003	-0.0003	0.0011	-0.0009	-0.0005	0.0004
Decrease of current account	-0.0008	-0.0013	0.0002	-0.0041	0.0002	-0.0006	0.0003	0.0005	0.0010	0.0003	0.0010	0.0018
Increase of official reserves	-0.0012	0.0013	0.0036	-0.0026	0.0008	0.0003	0.0002	0.0011	0.0007	-0.0005	-0.0006	-0.0008
Decrease of official reserves	0.0007	-0.0015	0.0023	-0.0002	0.0012	0.0009	0.0011	0.0019**	0.0015	-0.0009	-0.0021	-0.0012

Note: *** – denotes statistical significance at 1% level, ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

Table 8. Values of coefficients $\beta_{j,k=2}$ from equation (1), for $k = +2$ (representing 2 days lead)

$k = +2$ (i.e. 2 days lead)	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return
Interest rate above expectations	0.0013	-0.0012	0.0004	0.0007	-0.0017	-0.0032	-0.0021	-0.0015	-0.0034	-0.0004	0.0006	0.0012
Interest rate below expectations	0.0002	0.0041	0.0105	0.0029	-0.0062	-0.0054**	-0.0061	-0.0040	-0.0038	0.0055	0.0035	0.0025
Increase of interest rate	-0.0040	-0.0157**	-0.0018	-0.0041	-0.0004	-0.0011	-0.0003	0.0027	0.0028	0.0010	0.0028	0.0044
Decrease of interest rate	-0.0019	-0.0020	-0.0054	-0.0060	0.0046	0.0041*	0.0050	0.0033	0.0049	-0.0023	-0.0019	-0.0021
Money supply (M3) above expectations	0.0007	0.0081	0.0023	0.0007	-0.0005	-0.0011	0.0004	-0.0007	0.0006	-0.0014	-0.0024	-0.0032
Money supply (M3) below expectations	-0.0015	0.0018	0.0001	-0.0029	0.0007	0.0003	0.0010	0.0018	0.0006	-0.0015	-0.0021	-0.0024
Increase of money supply (M3)	0.0009	-0.0049	-0.0042	0.0024	-0.0005	0.0004	-0.0014	-0.0010	-0.0007	0.0012	0.0031	0.0040
Decrease of money supply (M3)	0.0040	0.0000	-0.0009	0.0022	0.0003	0.0008	0.0002	-0.0009	0.0006	0.0008	0.0046	0.0056
Current account above expectations	0.0033	0.0045	0.0042	0.0033	0.0001	-0.0008	-0.0006	0.0011	0.0005	0.0009	0.0009	0.0004
Current account below expectations	0.0055	-0.0012	0.0018	0.0057	0.0017	0.0009	0.0014	0.0011	0.0019	0.0010	0.0000	-0.0006
Increase of current account	-0.0057	-0.0020	-0.0015	-0.0062	-0.0007	-0.0004	-0.0000	-0.0001	-0.0003	-0.0010	0.0004	0.0005
Decrease of current account	-0.0055	-0.0011	-0.0039	-0.0062	-0.0008	-0.0006	-0.0005	-0.0005	-0.0009	-0.0003	0.0010	0.0014
Increase of official reserves	-0.0004	0.0035*	0.0018	0.0010	-0.001**	-0.001***	-0.0006	-0.0010	-0.0007	-0.0005	0.0002	0.0008
Decrease of official reserves	-0.0015	-0.0012	-0.0004	-0.0020	-0.0007	-0.0004	-0.0010	-0.0005	-0.0006	-0.0018***	0.0006	0.0016

Note: *** – denotes statistical significance at 1% level, ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

The results for $k = +1$ are illustrated in Table 6, which depicts much lower number of statistically significant cases (only 8 compared with 30 in previous Table 5 with the variant for $k = -1$) and it evidences that the most responsive instruments were bonds and currencies (4 cases each out of the total of 8 cases in the entire Table 6 with no significance at all in the stock market models), while the current account announcements were the most influential type of news followed by interest rate and M3 money supply (4, 2 and 2 cases, respectively).

Table 7 presents the results for the variant of models with lag $k = -2$, where the foreign exchange market was the most responsive market segment (with 8 cases of statistically significant estimates out of 13 cases in the entire Table 7) followed by bonds market (5 cases statistically significant estimates). The most dominant type of news by far were interest rates.

Finally, Table 8 with the results for $k = +2$ shows that, once again, there is a much lower number of instances of statistically significant estimates in the variants of models with leads than in the variants of models with the corresponding lags (only 7 *versus* 13 cases for lead $k = +2$ and lag $k = -2$, respectively). The foreign exchange market was the most responsive market segment (4 cases of statistically significant estimates) followed by the bonds market and the stock market (with 2 and 1 cases, respectively), whereas the most important types of announcements were official reserves and interest rate.[13]

5.2. Relevance of the Monetary Policy Council (MPC) Terms in Office

The sample period in our study spans across three terms in office of the three different Monetary Policy Councils (MPCs) of the National Bank of Poland, which over time included different members within those groups. The existing literature suggests

that the composition of the MPCs is important for the their decision-making processes and that it also matters for the perception of the MPC's decisions by the market participants from at least two points of view: (1) Proportions of the MPC members regarded as 'hawks' or 'doves' due to their approaches to monetary policy execution and (2) Voting consistency of the MPC members, which reflects the degree of the diversity or convergence of their views (see e.g. Ehrmann and Fratzscher (2005) and Bank for International Settlements (2009)).

In this section, we further explore this issue and we verify whether the financial market in Poland reacted similarly or differently depending on which MPC was in office and depending on the MPCs composition characteristics as well as the voting consistency of their members.

In order to do it, we constructed the following models with dummy variables capturing the three periods of the MPC terms (*MPC1*, *MPC2* and *MPC3*) and, additionally, we also control for the possible months of the year effects by adding the monthly dummies:

$$COUNT_t^x = \alpha + \beta \cdot MPCn + \sum_{m=Jan}^{M} \gamma \cdot DUM^m + \varepsilon_t \qquad (3)$$

where:

$COUNT_t^x$ – number of statistically significant events every month in three variants for x, where $x = 1$ for the count of events captured only by coefficients $\beta_{j,k=0}$ from equation (1) for $k = 0$ (i.e. statistically significant results only from Table 4), $x = 2$ for the count of events captured by coefficients $\beta_{j,k=0}$, $\beta_{j,k=-1}$ and $\beta_{j,k=1}$ from equation (1) for $k = 0$, $k = -1$ and $k = +1$ (i.e. statistically significant results from Tables 4, 5 and 6) and $x = 3$ for the count of events captured by coefficients $\beta_{j,k=0}$, $\beta_{j,k=-1}$, $\beta_{j,k=1}$, $\beta_{j,k=-2}$ and $\beta_{j,k=2}$ from equation (1) for $k = 0$, $k = -1$, $k = +1$, $k = -2$ and $k = +2$ (i.e. statistically significant results from Tables 4, 5, 6, 7 and 8),

$MPCn$ – dummy variables for three different terms of the three Monetary Policy Councils denoted as $n = 1, 2$ and 3, i.e. $MPC1$, $MPC2$ and $MPC3$,

DUM^m – dummy variables for months of the year, where: $m = Jan, Feb, Mar, Apr \ldots M$.

The terms of the Monetary Policy Councils over our whole sample period were as follows: $MPC1$ until December 2010, $MPC2$ from January 2011 until December 2016 and $MPC3$ from January 2017 onwards.

Estimation results of dummy variables parameters from model (3) are presented in Tables 9a, 9b and 9c.

The estimates for $MPC1$ are not significant in any variant, while the estimates for $MPC2$ are significant and positive in all cases in all three models for $COUNT_t^1$, $COUNT_t^2$ and $COUNT_t^3$ (as shown in Tables 9a, 9b and 9c). $MPC3$ is significant and negative in Tables 9b and 9c in models for $COUNT_t^2$ and $COUNT_t^3$. Therefore, these results clearly show the differences in the intensity of reactions to the NBP announcements depending on the period of the specific Monetary Policy Council term. In particular, the reactions of the financial market in Poland are more intensive during the second term of the Monetary Policy Council and they tend to be less intensive during its third term in office throughout our entire sample period.

When the composition of the MPCs is inspected more closely, there are no clear differences evident between the sub-groups of the MPC members regarded as ‘hawks’ or ‘doves’. The reasons for it are as follows. Firstly, the classifications of some MPC members as 'hawks' or 'doves' were not always obvious and, secondly, due to this issue it can not be stated with sufficiently high degree of certainty that the MPCs were always clearly dominated by one of these two sub-groups. Thus, this factor cannot be reliably used in an attempt to explain the intensity of market reactions.

Table 9a. Dummy variable estimates for the durations of the three Monetary Policy Councils terms in models of the count of the statistically significant announcements captured by coefficients $\beta_{j,k=0}$ from equation (1) for $k = 0$ (and controlled for the month of the year effects).

Dummy variable	Estimates					
MPC1	-0.318246 (-1.471192)	-0.300882 (-1.229553)	-	-	-	-
MPC2	-	-	0.345607 ** (2.400753)	0.344154 ** (2.060266)	-	-
MPC3	-	-	-	-	-0.248597 (-1.527364)	-0.240129 (-1.003754)
Jan	-	0.168377 (0.354670)	-	0.197977 (0.373034)	-	0.222712 (0.433906)
Feb	-	-0.128640 (-0.338741)	-	-0.101626 (-0.276657)	-	-0.074222 (-0.191952)
Mar	-	0.472465 (1.199688)	-	0.500574 (1.243576)	-	0.525410 (1.391549)
Apr	-	-0.226655 (-0.682358)	-	-0.197973 (-0.547204)	-	-0.172794 (-0.506071)
May	-	0.275637 (0.694914)	-	0.302707 (0.759987)	-	0.327484 (0.900772)
Jun	-	0.153743 (0.399510)	-	0.154021 (0.403135)	-	0.177212 (0.444746)
Jul	-	0.035235 (0.082465)	-	0.045206 (0.105308)	-	0.067094 (0.167614)
Aug	-	-0.439786 (-1.144763)	-	-0.425522 (-1.051331)	-	-0.407518 (-1.033751)
Sept	-	-0.307223 (-0.769382)	-	-0.299857 (-0.723426)	-	-0.300676 (-0.731614)
Oct	-	0.245667 (0.638993)	-	0.242783 (0.648347)	-	0.257017 (0.638747)
Nov	-	0.208136 (0.491758)	-	0.206192 (0.495032)	-	0.209032 (0.545102)

Notes: (1) t-statistics in brackets. (2) *** – denotes statistical significance at 1% level, ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

Table 9b. Dummy variable estimates for the durations of the three Monetary Policy Councils terms in models for the count of the statistically significant announcements captured by coefficients $\beta_{j,k=0}$, $\beta_{j,k=-1}$ and $\beta_{j,k=1}$ from equation (1) for $k = 0$, $k = -1$ and $k = +1$ (and controlled for the month of the year effects).

Dummy variable	Estimates					
MPC1	-0.194484 -0.635034)	-0.209920 (-0.417467)	-	-	-	-
MPC2	-	-	0.599160 *** (3.002822)	0.593302 *** (2.911561)	-	-
MPC3	-	-	-	-	-0.633520 *** (-2.838438)	-0.641001 ** (–2.391541)
Jan	-	-0.379045 (-0.679794)	-	-0.090861 (-0.142840)	-	-0.067151 (-0.097721)
Feb	-	-0.838435 * (-1.734373)	-	-0.374048 (-0.852847)	-	-0.351335 (-0.747526)
Mar	-	0.279771 (0.630238)	-	0.450419 (1.064605)	-	0.503620 (1.206989)
Apr	-	-0.543183 (-1.415969)	-	-0.376934 (-0.929938)	-	-0.343125 (-0.784313)
May	-	0.016082 (0.038320)	-	0.231398 (0.523761)	-	0.297667 (0.693885)
Jun	-	-0.201095 (-0.390191)	-	0.118847 (0.270161)	-	0.142487 (0.304349)
Jul	-	-0.448264 (-1.027798)	-	-0.117032 (-0.281010)	-	-0.087941 (-0.201679)
Aug	-	-1.565096 *** (-3.305559)	-	-1.181481 * (-1.788422)	-	-1.130866 ** (-1.976514)
Sept	-	-0.915425 ** (-2.101621)	-	-0.696580 * (-1.696069)	-	-0.656671 (-1.422630)
Oct	-	-0.263620 (-0.512505)	-	0.062678 (0.121355)	-	0.109272 (0.213498)
Nov	-	-0.578872 (-1.169536)	-	-0.185164 (-0.399755)	-	-0.249538 (-0.548307)

Notes: (1) t-statistics in brackets. (2) *** – denotes statistical significance at 1% level, ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

Table 9c. Dummy variable estimates for the durations of the three Monetary Policy Councils terms in models for the count of the statistically significant announcements captured by coefficients $\beta_{j,k=0}$, $\beta_{j,k=-1}$, $\beta_{j,k=1}$, $\beta_{j,k=-2}$ and $\beta_{j,k=2}$ from equation (1) for *k = 0*, *k = -1*, *k = +1*, *k = -2* and *k = +2* (and controlled for the month of the year effects).

Dummy variable	Estimates					
MPC1	-0.086280 (-0.323790)	-0.102672 (-0.232835)	-	-	-	-
MPC2	-	-	0.619832 *** (3.636027)	0.659269 *** (3.109682)	-	-
MPC3	-	-	-	-	-0.720529 *** (-3.813414)	-0.766925 *** (-3.190704)
Jan	-	-0.408660 (-0.793844)	-	-0.399754 (-0.587282)	-	-0.323139 (-0.560291)
Feb	-	-0.507633 (-1.453286)	-	-0.499750 (-1.316579)	-	-0.423144 (-1.132887)
Mar	-	0.093147 (0.227365)	-	0.100467 (0.235980)	-	0.176959 (0.460444)
Apr	-	-0.406244 (-0.993090)	-	-0.399751 (-0.946413)	-	-0.323203 (-0.796770)
May	-	0.294639 (0.724113)	-	0.301129 (0.687143)	-	0.377202 (0.960894)
Jun	-	-0.115415 (-0.280222)	-	-0.110912 (-0.260259)	-	-0.044073 (-0.110467)
Jul	-	-0.294284 (-0.709802)	-	-0.299338 (-0.722773)	-	-0.237089 (-0.615938)
Aug	-	-1.277559 *** (-2.919765)	-	-1.298850 ** (-2.337110)	-	-1.237966 ** (-2.478820)
Sept	-	-0.806814 ** (-2.090561)	-	-0.824564 ** (-2.024225)	-	-0.775668 ** (-2.036811)
Oct	-	-0.038670 (-0.096177)	-	-0.076659 (-0.187601)	-	-0.025946 (-0.067446)
Nov	-	-0.402485 (-1.126760)	-	-0.400236 (-0.897121)	-	-0.400134 (-0.994624)

Notes: (1) t-statistics in brackets. (2) *** – denotes statistical significance at 1% level, ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

Hence, we next turn our attention to the patterns of voting regarding the most important decisions about interest rates. This information is recorded in the voting reports with the summaries of the Monetary Policy Council members' voting results and it is publicly available from the NBP.[14]

Ehrmann and Fratzscher (2005) argue, based on their analysis of data from the Federal Reserve in the USA, the Bank of England in the UK and the European Central Bank (ECB), that communicating the diversity of views among the MPC committee members about the monetary policy lowers the market's ability to anticipate policy decisions as well as the future path of interest rates. The study by Ehrmann and Fratzscher (2005) concludes that it is the collegiality of views on the monetary policy that enhances the effectiveness of central bank communication.

Our results, reported so far in Tables 4 – 8, are directly applicable in the investigation of this matter for the Polish central bank's MPCs decisions and the related reactions of the financial market in Poland. We combine them below with a detailed analysis of the proportions of 'for' and 'against' votes regarding the interest rates decisions, which were subject to voting by all three MPC councils. This data, extracted directly from the MPCs voting reports, allowed us to construct a measure of dispersion of MPC members' views.

We define the views dispersion measure using $\mathcal{N}$ operator as follows:

$$DISP = \frac{\sum_{d=1}^{D} |\mathcal{N}(for)_d - \mathcal{N}(against)_d|}{D} \tag{4}$$

where:

$\mathcal{N}(for)_d$ – is the number of 'for' votes for the voted motion at the MPC meeting d,

$\mathcal{N}(against)_d$ – is the number of 'against' votes for the voted motion at the MPC meeting d,

D – is the total number of voted motions at the MPC meetings during the entire MPC term.

The measure $DISP$ directly captures the dispersion of votes of the MPC members. Higher values of $DISP$ mean lower dispersion of views (or: stronger agreement) of the MPC members, while its lower values indicate higher degree of disagreement of views (with $DISP = 0$ meaning that the same numbers of MPC members voted 'for' and 'against' a particular motion).

In the investigated sample period in this paper, there was only one interest rate change during the first term of the MPC, but there was no reporting requirement at that time regarding the voting results and the voting report does not exist in this one particular instance, so the interest rate voting decisions were not possible to compare for the first MPC term (however the $MPC1$ dummies estimates were not significant in our models either). Hence, we could conduct a comparison only for the decisions in the next two MPC terms.

The key result is that the value of $DISP$ measure during the second term was 4.64, while in the third term it was substantially higher and it reached the value of 6.31. Such difference implies that the MPC members during the second term in office voted with slimmer majority of votes, which represents a larger divergence of the MPC members' opinions. In the third MPC term the voting pattern was more consistent indicating higher degree of agreement of the MPC members' views.

This finding means that greater diversity of the MPC members' opinions is associated with more cases of statistically significant NBP communication events during the second term of the MPC, while higher degree of collegiality of their views occurring in the third term coincided with the lower number cases of statistically significant NBP communication events.

Therefore, following Ehrmann and Fratzscher (2005), we can interpret this result that the effectiveness of the Polish central bank's communication was enhanced in the most recent period during the third term of the Monetary Policy Council in office.

6. Analysis in the Out–of–Sample Period

Results reported so far focus predominantly on the statistical significance of the estimated parameters, which we detected in our models. In this section, we now attempt to answer the question about what is the economic significance of our findings by constructing a trading strategy in the out–of–sample period, which relies directly on the in–sample estimations, and by investigating its performance.

The estimates presented in Tables 4 – 8, which capture the impact of the NBP communication on the movements of the assets' prices, show evidence of appreciation and depreciation effects in response to the Polish central bank's monetary policy decisions. Therefore, we now turn to investigating in more details whether events such as the release of new data by the NBP may create profit opportunities for the financial market investors. In order to do it, we constructed an investment strategy and analysed the possible profits and losses from trades based on the statistically significant estimates (at the level at least $p < 0.10$) of the dummy variables lagged by one day (i.e. for $k = -1$) from Table 5.

Due to the fact that the NBP announcements were always made in the afternoon at 2:00 p.m., for the out–of–sample analysis presented in this section we use the intra–daily 1–minute frequency data to measure the profitability of trades based on the statistically significant dummies. Following Brzeszczyński and Kutan (2015), we argue that many traders are likely to transact within rather short time horizons in response to such news as public information contained in the central bank announcements.

Therefore, the reason why we use intra–daily frequency, and examine in such detail the changes in the assets' prices over these very short periods of time, is that any such investigation should consider investment horizons finer than just 1 day intervals

Our trading rule is as follows. We assume that an investor opens a *long position* in the particular asset on the day when there is the NBP announcement, which was found in results in Table 5 to be statistically significant (at the level at least $p < 0.10$) and had a *positive* sign, or an investor opens a *short position* when there is an announcement, which in Table 5 was found to be statistically significant (at the level at least $p < 0.10$) and had a *negative* sign. The only exception to this rule are bonds, because the bonds models in the in–sample period analysis are constructed using bonds yields as the dependent variable, while the trading strategy relies on buying or selling the particular assets using their prices, so the generated signals to trade must predict price changes. Hence, because of the inverse relation between bond's price and its yield, the *negative* sign of the estimated coefficient implies the decrease of the bond's yield, which means the increase of the bond's price, so it ultimately indicates opening of a *long position*. Similarly, a *positive* sign of the estimate in the bond's model predicts opening of a *short position*.

The simulated positions are closed at the end of the investment horizon, i.e. at the end of day $t+1$. The reason why we use the estimates from Table 5 from the models with the lagged dummy variables by one day, rather than from Table 4 with the variants of models with dummy variables without lags (so in the out–of–sample period this is also, naturally, reflected in the one day shift between day t and day $t+1$), is that the NBP announcements were released always in the afternoon at 2:00 p.m., i.e. shortly before the markets become less active and close soon afterwards (the trading session at the Warsaw Stock Exchange ends at 5:00 p.m.), so the simulation of the transactions based on the estimates from models without lags would not make much sense

(because the daily returns cover the whole day period from 9:00 a.m., while such trades could only be executed for the small fraction of the day at its end, i.e. after 2:00 p.m.). Hence, in this section we focus mainly on the investigation of the results of the strategy during the next day $t+1$, although for the robustness analysis purposes we also checked its performance on day t from 2:00 p.m. until the end of the day at 5:00 p.m.

We examined the performance of this trading strategy for days t and $t+1$, which is illustrated in Table 10 and, also, in more details further in Table 11, which allowed us to present differences between a broader spectrum of very detailed intra-daily results.

The in–sample estimations cover the period until 24th June 2019, so the out–of–sample analysis starts on 25th June 2019. The out–of–sample period includes over 7 months and it ends on 15th February 2020.

During the entire out–of–sample period there were no interest rate changes made by the NBP in Poland, so we could not use this particular type of the NBP announcement, however we could exploit the information about the publication of other monetary policy data. Ultimately, we have identified 11 announcements in the out–of–sample period, which include: decrease of M3 money supply, increase of official reserves and increase of current account, i.e. there is a total of 11 events in the bonds market and in the stock market (while there were no cases of statistically significant estimates in Table 5 for these types of announcements in the foreign exchange market models).

Table 10 presents returns from our investment strategy for trades that are executed based on the rules described above.

The results in Table 10 demonstrate that such strategy would be profitable in most cases in the investment horizon defined as the end of day $t+1$, but its performance is much worse on day t. At the end of day 1, the individual trades for all 11 events are

profitable in only 5 out of 11 instances, while at the end of day $t+1$, the individual trades for those 11 events are profitable in as many as 8 out of 11 cases.

Therefore, it is evident that the profits only materialize on day $t+1$ consistently with the statistically significant estimates reported in Table 5.

The patterns of intra–daily performance of all 11 trades using 1–minute frequency data, as well as the overall pattern of their combined performance, is illustrated in graphs in Figure 2.

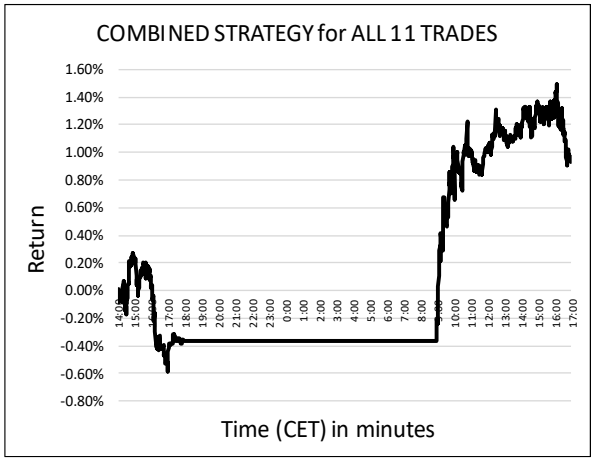
In particular, the first graph for the combined strategy depicts that it would, in fact, deliver the loss on day t during the interval from 2:00 p.m. until the end of the day at 5:00 p.m. and it also shows the pattern of profitability during day $t+1$ from 9:00 a.m. until 5:00 p.m. with the peak at 4:00 p.m.

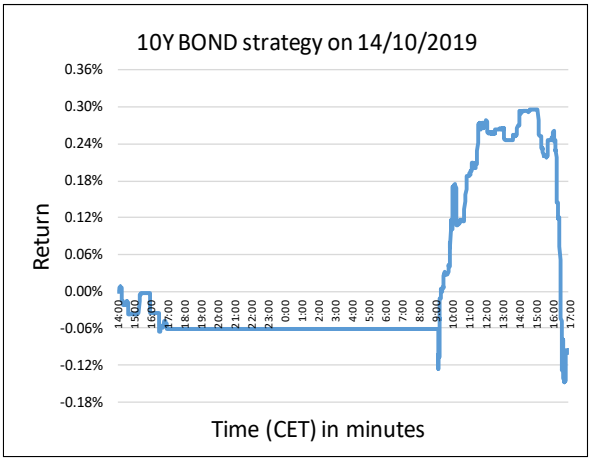
Table 10. Investment strategy results in the out–of–sample period from 25th May 2019 to 15th February 2020 on days t and $t+1$

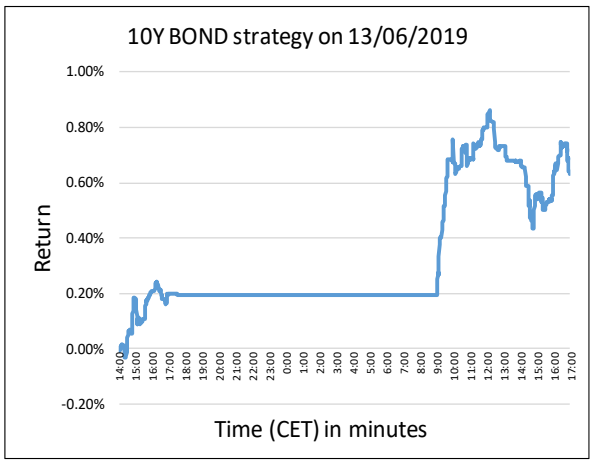
Profit / loss for individual trades for all the events on day t										
Event:										
1	2	3	4	5	6	7	8	9	10	11
0.20%	0.04%	-0.06%	0.01%	-0.07%	-0.44%	-0.21%	0.13%	-0.05%	0.03%	-0.03%
Profit / loss for individual trades for all the events on day $t+1$										
Event:										
1	2	3	4	5	6	7	8	9	10	11
0.63%	0.03%	-0.10%	0.21%	0.05%	0.16%	0.10%	0.15%	-0.08%	0.12%	-0.32%

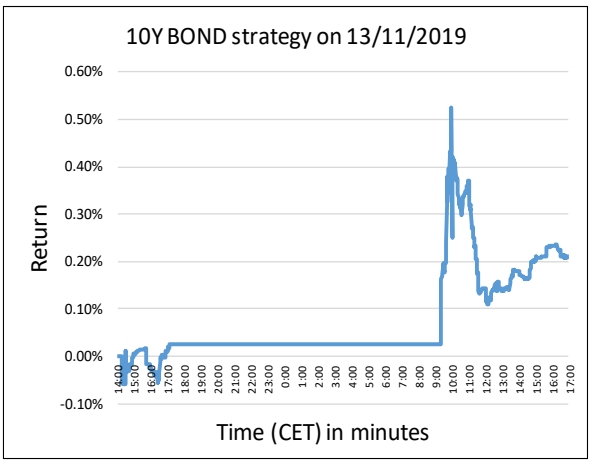
Note: Results highlighted in grey indicate positive returns.

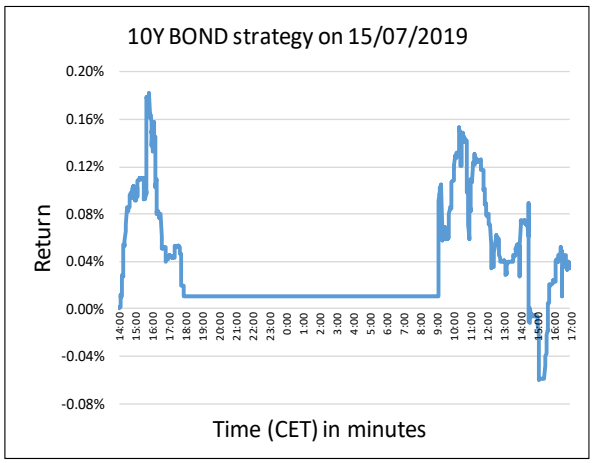
Figure 2. Performance of trading strategies in the out–of–sample period from 25th May 2019 to 15th February 2020 for all individual 11 trades and their combined performance











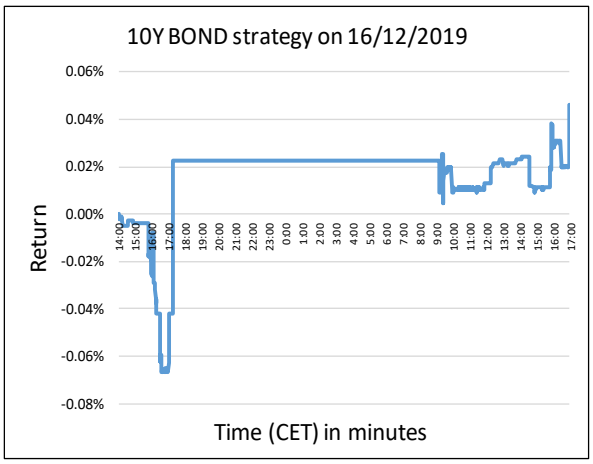
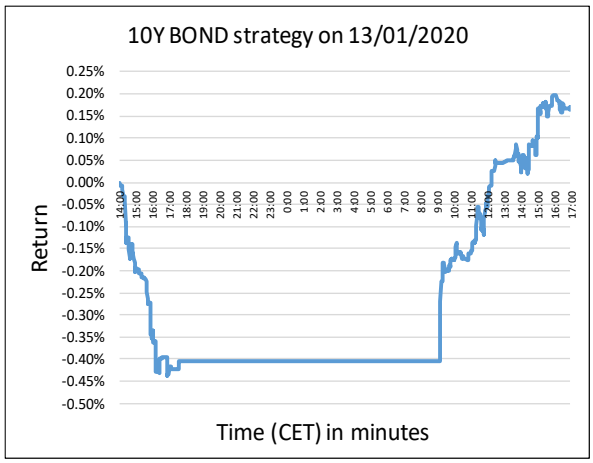
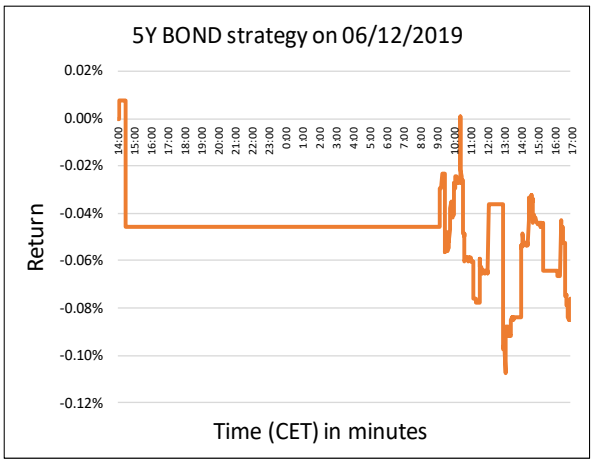
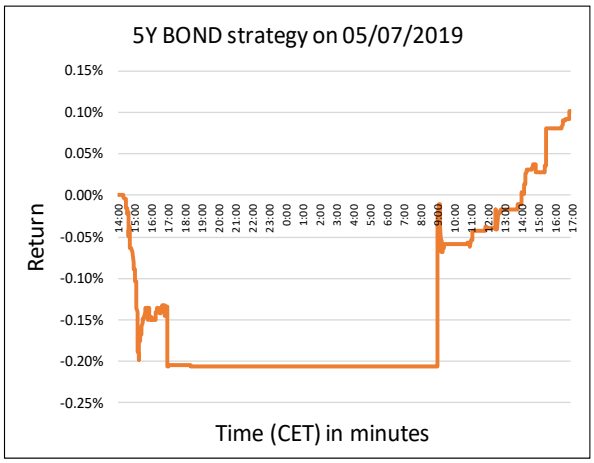
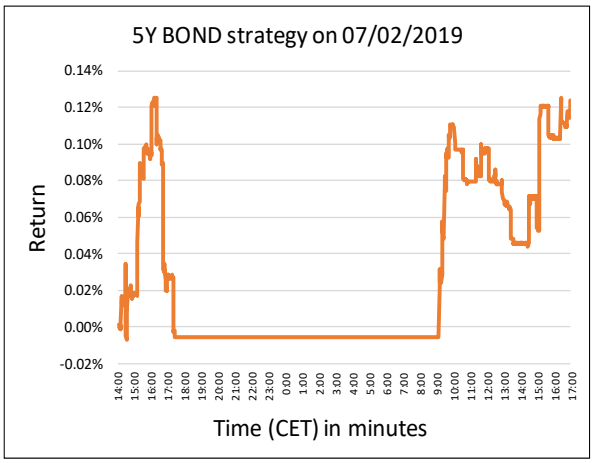


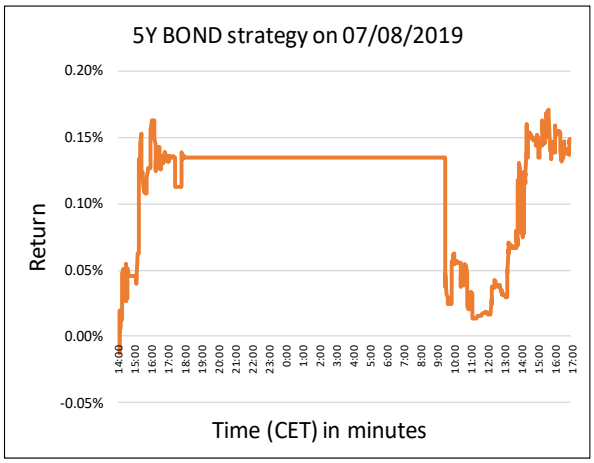
Figure 2. (continued)

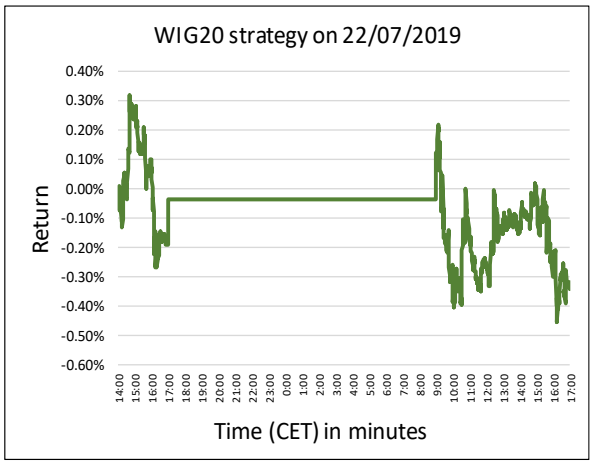












We further verified whether the changes in the effects of the NBP monetary policy announcements between the trading strategies executed on day t and on day $t+1$ are statistically significant.

For this purpose, we applied the t-test for equality of means for the returns from all the investigated investment horizons covering days t and $t+1$, which are divided by 1-hour intervals from +1 hour through +3 hours (i.e. end of day t) until +27 hours (i.e. end of day $t+1$). The trading horizons are defined as the intervals of time *between* the NBP announcements (made always at 2:00 p.m.) *and* the following points of time denoted in Table 11 as: '+1 hour', '+2 hours', '+3 hours (i.e. end of day t)' for day t and from '+19 hours' to '+27 hours (i.e. end of day $t+1$)' for day $t+1$.

Table 11 reports the t-test statistics with their respective significance levels for all combinations of trading horizons from +1 hour to +27 hours. They show that the highest returns have been achieved towards the end of day $t+1$ around 3:00 – 4:00 p.m. in the afternoon (corresponding with the investment horizon of +25 and +26 hours since the NBP announcement at 2:00 p.m. on previous day t), but not at the very end of day $t+1$ at 5:00 p.m. The t-test statistic is significant for the differences in returns between the end of day t (i.e. +3 hours at 5:00 p.m.) and returns on day $t+1$ after +24 hours (i.e. at 2:00 p.m.), after +25 hours (i.e. at 3:00 p.m.) and after +26 hours (i.e. at 4:00 p.m.).

These results clearly show that the changes in the effects of the NBP monetary policy announcements between the trading strategies on days t and $t+1$ are statistically significant indeed and they manifest themselves most strongly in case of differences between the returns at the end of day t and the returns achieved on day $t+1$ by around 2:00 – 4:00 p.m. (but not at the very end of day $t+1$ at 5:00 p.m.).

Table 11. Values of *t*-test for equality of means for the trading strategies' returns among all investment horizons covering days *t* and *t+1* divided by 1-hour intervals from +1 hour through +3 hours (i.e. end of day *t*) until +27 hours (i.e. end of day *t+1*).

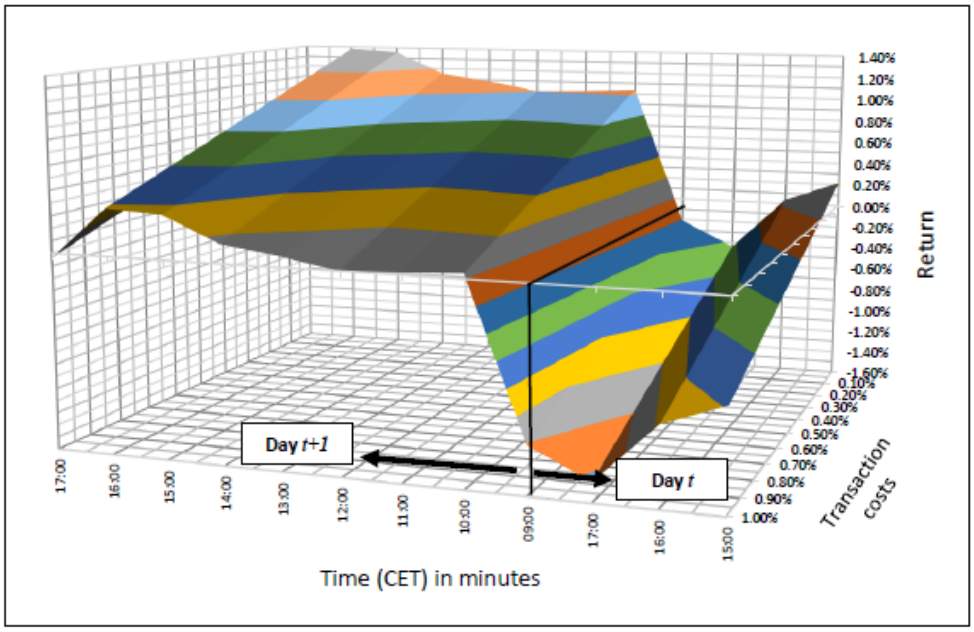
Trading horizons on days *t* and *t+1* from NBP announcement at 2:00 p.m. CET on day *t*:	+2 hours	+3 hours (i.e. end of day *t*)	+19 hours	+20 hours	+21 hours	+22 hours	+23 hours	+24 hours	+25 hours	+26 hours	+27 hours (i.e. end of day *t+1*)
+1 hour	-0.288529	-0.96252	-0.641861	0.75125	0.878269	0.788813	0.977159	1.126609	1.579285	1.396253	0.829867
+2 hours	-	-0.625639	-0.329977	0.886213	1.023471	0.93258	1.120157	1.263189	1.681781	1.514752	0.981907
+3 hours (i.e. end of day *t*)	-	-	0.290953	1.278916	1.475903	1.362382	1.586912	1.74512 *	2.204089 **	1.990542 *	1.452686
+19 hours	-	-	-	1.088616	1.255701	1.15375	1.359086	1.508832	1.943879 *	1.755615 *	1.223699
+20 hours	-	-	-	-	-0.015155	-0.036575	0.023245	0.087311	0.253271	0.262426	-0.077501
+21 hours	-	-	-	-	-	-0.024505	0.043927	0.117833	0.31485	0.318019	-0.070305
+22 hours	-	-	-	-	-	-	-	0.137994	0.324942	0.328461	-0.041929
+23 hours	-	-	-	-	-	-	-	0.074888	0.276002	0.281564	-0.117753
+24 hours	-	-	-	-	-	-	-	-	0.202707	0.214004	-0.196649
+25 hours	-	-	-	-	-	-	-	-	-	0.032115	-0.409059
+26 hours	-	-	-	-	-	-	-	-	-	-	-0.403714

Note: Results highlighted in grey indicate statistically significant test results, where: ** – denotes statistical significance at 5% level and * – denotes statistical significance at 10% level.

Finally, we also take into account the cost of trading in the execution of such an investment strategy.

Figure 3 illustrates the performance of the combined strategy with different levels of transaction costs. It shows the same pattern of profitability on day $t+1$ with the jump between 9:00 a.m. and 10:00 a.m. and the peak at 4:00 p.m. Between 10:00 a.m. and 5:00 p.m. this strategy is robust to trading costs adjustments and it always delivers positive results even after inclusion of relatively high levels of transaction costs.[15]

Figure 3. Performance of combined strategy in the out–of–sample period from 25th May 2019 to 15th February 2020 with different levels of transaction costs



In summary, we analysed a variety of different investment horizons, and we detected a clear and consistent pattern of possible profit opportunities for the investors who responded to the NBP announcements, for which there were statistically significant estimates of the NBP announcements dummy variables. This is an important finding that has practical implications for the financial market investors.

7. Discussion

Results presented in this study clearly highlight the dominance of two types of announcements published by the NBP central bank in Poland, i.e. interest rates and money supply, which consistently exerted the strongest influence on assets' prices in the broader financial market.

The analysis based on models using the data from all 3 market segments also reveals that the bonds market and the foreign exchange market had the highest sensitivity.

Tables 12 and 13 present a further breakdown of the statistically significant estimation results for the dummy variables from all models reported in Tables 4 – 8.

Table 12 shows that the interest rate changes were the most dominant type of news (35 cases). They were followed by the money supply announcements (14 cases). The other two announcements, i.e. official reserves and current account, were less important (with only 9 and 7 cases reported in Table 12, respectively).

As Table 12 further illustrates, the bonds market and the foreign exchange market were the most responsive market segments. The 5 year bond was the most sensitive instrument. Among the foreign exchange rates, the GBP/PLN was the most responsive currency pair. In case of the stock market, only the sWIG80 and the blue–chip index WIG20, which includes the largest and most liquid companies, reacted to the NBP communication.

Table 13 indicates that the changes of the revealed new macroeconomic figures of the NBP central bank influenced the financial market more than the deviations from the expectations (22 and 13 cases *versus* 18 and 12 cases, respectively). Once again, the bonds market proved to be the most sensitive market segment.[16]

Table 12. Number of statistically significant (at p–value: 0.01, 0.05 or 0.10) coefficients' estimates for given instrument and type of announcement

Type of announcement:	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return	SUM:
Interest rate	3	6	6	7	2	2	4	4	1	0	0	0	35
Money supply (M3)	3	0	1	1	2	0	3	1	1	0	0	2	14
Current account	1	0	0	1	2	2	1	0	0	0	0	0	7
Official reserves	1	1	0	2	1	1	0	1	0	2	0	0	9
SUM:	8	7	7	11	7	5	8	6	2	2	0	2	65

Note: Every column presents the numbers of statistically significant estimates for each of 12 equations given by equation (1). Table 12 contains a summary of results for the variants of models with dummy variables with lags and leads spanning from lag -2 to lead +2, which are presented in details in Tables 4–8.

Table 13. Number of statistically significant (at p–value: 0.01, 0.05 or 0.10) coefficients' estimates for given instrument and direction of the change in announcement value

Type of change:	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return	SUM:
Increase	3	2	0	3	2	2	1	0	0	0	0	0	13
Decrease	2	2	2	4	2	1	2	3	1	2	0	1	22
Above expectations	0	1	2	1	1	1	3	1	1	0	0	1	12
Below expectations	3	2	3	3	2	1	2	2	0	0	0	0	18
SUM:	8	7	7	11	7	5	8	6	2	2	0	2	65

Note: Every column presents the numbers of statistically significant estimates for each of 12 equations given by equation (1). Table 13 contains a summary of results for the variants of models with dummy variables with lags and leads spanning from lag -2 to lead +2, which are presented in details in Tables 4–8.

The overall finding from this study indicating clearly that bonds market and the foreign exchange market had the highest sensitivity is not surprising, because interest rate movements are, in fact, directly related to the bonds' prices through the bond's pricing model relationships, which link the bonds' future cash flows with the interest rate that is used for discounting them. In the foreign exchange market, in turn, the transmission channel relies on the capital flows, which are triggered by changes in interest rates and money supply. In case of currencies, they manifest themselves, therefore, through the covered or uncovered interest rate parity relations. The responsiveness of the stock market is weaker, and the transmission channels there also depend on the capital flows, which in this instance cause shifts in demand and supply for/of stocks leading to the corresponding reactions of stock prices.

More specifically, our results can be further explained as follows. *First*, in a small open economy, interest rate parity depends on the liquidity premium determined by differences in liquidity in the financial markets between home and foreign country as well as the expected change in the exchange rate. Therefore, our results showing that bonds market reacts with more sensitivity than stock market to central bank's announcements may be explained by different liquidity premia components in the bonds and stock markets. *Second*, asset prices react to central bank communication if it is relevant to market participants in terms of the policy inclination or economic outlook and risks. As long as stock market investors tend to be relatively more long-term investors than bonds market investors, they may react to communication signalling because of more permanent (long-term) changes in economic outlook or policy. If central bank communication is more short-term oriented, then stock market participants may see it as less relevant and, hence, react with less sensitivity to it.

As further robustness check of our findings, we also estimated variants of models with alternative definitions of control variables in form of residuals obtained from regressing the global control variables (capturing global effects of monetary policy announcements) against the respective local instrument as dependent variable in our models (capturing relevant local effects). Summary of these results is presented in the Appendix in Tables A1 and A2, which show that there is exactly the same number of statistically significant cases (i.e 65 instances across all 3 markets) as in the models with the control variables without the adjustment. The pattern of results is also very similar: in terms of the degree of responsiveness, the most sensitive instruments are bonds followed by currencies and then the stock market (as it is evidenced by Table A1, which reports 36, 22 and 7 cases, respectively, with 33, 28 and 4 cases, respectively, in Table11). With regard to the type of announcements, once again the most important ones by far prove to be interest rates and then money supply, official reserves and current account data (32, 17, 10 and 6 *versus* 35, 14, 9 and 7 instances, respectively, in Table 12 and Table A1 in the Appendix). Moreover, the structure of the statistically significant estimates for the types of changes is very similar too, which is illustrated through a direct comparison of Table 13 and Table A2 in the Appendix. Therefore, the inclusion of alternative control variables did not alter the key findings, which consistently show that bonds market is the most sensitive one, while the stock market is the least responsive segment, whereas interest rates are the most influential types of monetary policy decisions news.

Summarising, we can conclude that the results presented in our study provide robust evidence that the NBP central bank monetary policy news communication with financial market in Poland significantly affected assets' prices during our sample period in years 2009 – 2019.

Our findings are generally consistent with the results from developed markets (such as Bernanke and Kuttner (2005), Bekaert, Hoerova and Lo Duca (2013), Lucca and Moench (2015) and Cieślak, Morse and Vissing-Jorgensen (2019)) and with previous studies using emerging market data from Poland. In particular, our paper reports similar effects of the central banks' communications as the earlier studies by Brzeszczyński and Kutan (2015) and Brzeszczyński, Gajdka and Kutan (2017), which also detected statistically significant reactions of different financial instruments to the NBP announcements with interest rates and money supply as the most influential type of news. Our work, however, is much more comprehensive, because it relies on the larger number of market segments and instruments analysed in one study as well as on longer and more recent data sample. Therefore, our results may be generalized under different time periods, i.e. early transition periods *versus* periods of a more matured emerging market economy, and may have relevance for analyses of other emerging markets, which have been implementing similar economic reforms, including the establishment of an independent central bank, as it was the case in Poland.

Finally, we explored the profit opportunities based on the statistically significant estimates of the NBP announcements dummy variables in the in–sample period, which can be used as predictors for trades out–of–sample. We found that for a number of different investment horizons and different levels of transaction costs such profit opportunities did, in fact, exist. The patterns of results from the trading strategy reported in this study broadly confirm also the findings presented earlier by Brzeszczyński and Kutan (2015), who concluded too that the NBP communication with financial markets affected investors' reactions on the emerging market in Poland during the early years of their sample period from 2000 to 2003 and indicated the existence of some profit opportunities. Again, our evidence relies, however, on an extended data

sample until the year 2020 and on a much larger number of market segments and instruments.

The finding about the existence of profit opportunities relying on trades based on the NBP announcements is related to a very relevant practical matter that, at the same time, concerns also a very important theoretical issue regarding market efficiency.

In Poland this issue is directly linked to liquidity. Based on the value and frequency of transactions, the bonds market is the least liquid one and the stock market is the most liquid segment, while the foreign exchange market in the Polish currency (PLN) is positioned between them as moderately liquid (which additionally depends also on the particular currency pair against the PLN with EUR/PLN or USD/PLN more liquid than e.g. CHF/PLN or JPY/PLN etc.). It needs to be emphasized too that although liquidity can be measured in many different ways, and there exist many measures to capture this phenomenon, liquidity in Poland is highly dependent on the frequency of trading, which is very low in the bonds market and also in the foreign exchange market it is lower than on the stock market.

This pattern of liquidity across all 3 market segments in Poland is highly consistent with the pattern of the estimation results from our models reported in Tables 4 – 8 (and also in the Appendix in Tables A1 and A2), where the biggest number of statistically significant estimates of dummy variables parameters was found in the bonds models, followed by foreign exchange rates models and then stock market models.

In addition, it is worthwhile to note that these relations are also visible within certain sectors, which additionally supports the existence of a link with liquidity. For example, in the bonds models there are more cases of the statistically significant estimates of the dummy variables parameters for the least liquid bonds (with longer

maturities) than in case of more liquid bonds (with shorter maturities), i.e. 19 cases for 10 years and 5 years bonds and 14 cases for 2 years and 1 year bond (with 22 and 14 cases, respectively, in the versions of models with alternative control variables).

Therefore, we interpret our findings in light of different levels of liquidity across all 3 market sectors, which suggests also different levels of market efficiency, leading to a conclusion about the unexploited investment opportunities that do not disappear immediately after the release of the NBP announcements (however with different degrees of market (in)efficiency across these 3 segments in line with their varying levels of liquidity).

8. Conclusions

The results of our analysis suggest that the National Bank of Poland has been affecting the domestic financial market and that the investors react to its monetary policy news. Moreover, the effectiveness of the Polish central bank's communication seems to have been enhanced in the most recent period during the last term of the Monetary Policy Council in office, which has been characterised by higher degree of collegiality of its members' views. Such behavior of the broader financial market has obvious implications for, for example, fund managers etc.

There also exist broader policy implications of our findings for other emerging markets.

First, the results reported in this paper suggest that central bank communication in the emerging economies can trigger assets' prices movements as a response to important announcements that these institutions regularly make. *Second*, this kind of an impact on prices can, on one hand, generate wealth effects but, on the other hand, can also create volatility (or: risk) effects. In consequence, the investors in emerging

markets, as our study using the Polish data demonstrates, need to be aware of the influence that the central banks may have on financial assets and should incorporate in the respective decision–making processes (or at least: anticipate) their actions. *Third*, both individual and institutional investors can create profitable trading strategies based on the central banks announcements, in particular over ultra-short intra-daily time horizons (as we show in this study), and they can also adjust their portfolios of financial assets in order to increase or decrease exposure to certain risks. *Fourth*, our results, showing that central bank communication affects asset prices in bonds market more than in stock market, have important social welfare and economic implications. The retired community and some public relying on investment profits in financial markets to smooth out their consumption behaviour need to be cautious in investing in bonds market from a short-run perspective as central bank communication may generate more volatility (risk) in this market in the short run. These investors are better off investing in stock market with a long-term focus. *Fifth*, results presented in this study indicate also the importance of conducting a transparent and effective central bank communication for financial stability. Such communication enhances the credibility of a central bank's actions and thus helps to maintain low inflation and a stable macroeconomic and financial environment with less frequent business cycles providing more stable cost of living and employment rates. This also raises social and economic welfare. *Sixth*, similarly to developed markets, the communication of central banks can be an important and effective monetary policy transmission mechanism in emerging market economies. *Seventh*, our results also have very direct implications for the assessment of market efficiency of different segments of the broader financial market, because the differences in reactions to the central bank’s news, in conjunction with the analysis of their liquidity, may further provide important knowledge in that regard as

well as may contribute to a better understanding of market efficiency as a financial concept.

Regarding future research, our evidence from Poland, as the largest Central and Eastern European economy, may provide a yardstick for other emerging markets in the region, that also went through significant economic re-structuring and policy reforms, as well as for other emerging markets around the world.

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Endnotes:

[1] Policymakers also have been undertaking recently various actions, which aim at increasing central banks transparency and co-ordinating the existing codes of practice in this area. For example, the International Monetary Fund (IMF) in 2020 published a document, called *"The Central Bank Transparency Code – Staff Proposal"*, which is a voluntary code proposal, composed of a comprehensive, central bank-focused set of principles and practices. The Central Bank Transparency (CBT) code is solely focused on central banks and it aims to encompass their broad range of mandates, governance frameworks and institutional arrangements. It is intended to allow central banks to map their transparency frameworks, improve the dialogue with their stakeholders and contribute to policy effectiveness. Central banks are encouraged in the CBT code to assess their existing transparency frameworks using the CBT as a guide and allow for more informed central bank choices on transparency and more effective communication between the central bank and its various stakeholders. IMF expects that a better understanding of the rationale for central bank mandate, governance, policies, operations, outcomes and official relations will reduce uncertainty and facilitate a public dialogue that can anchor public expectations and foster better policies. CBT code also recommends that central banks should actively engage with the public and stakeholders on its communication policy and actively evaluates their communication policy through, for example, surveys. These activities should be further described in the central banks' annual reports (see: International Monetary Fund (2020)).

[2] For example, in the year 2012 the WSE was the most active market not only in the CEE region but also in the whole Europe. The issuers listed on the WSE represented about 51% companies from the region's exchanges and their share in equities trading in Central and Eastern Europe went up to 54.2% in 2012 (see: Fact Book 2013. Warsaw Stock Exchange (2013)).

[3] See: Catalyst Report – Development Brief (2012).

[4] For a broader review of the literature on the link between public announcements and financial markets' reactions in emerging market countries see: Brzeszczyński, Gajdka and Kutan (2015).

[5] Related recent literature has been dealing also with the issue of the investors' demand for information ahead of the economic announcements and, in particular, about macroeconomic factors affecting the path of future interest rates as a measure of their uncertainty. In a recent study regarding this matter, Benamar, Foucault and Vega (2021) found that an increase in information demand before the influential economic announcements affecting investors' beliefs about future interest rates predicts a stronger reaction of the U.S. Treasury note yields to these news.

[6] Due to space limitations and the focus of our study, we review in this section mainly the papers, which investigate impact on assets' prices or their returns. However, it needs to be mentioned that there exists also a related literature, which analyses the effects of central banks' communication, their specific actons and the level of their transparency on the volatility of assets' prices and on the resolution of uncertainty among the investors (see e.g. the publications by Nikkinen, Omran, Sahlström and Äijö (2006), Loiseau–Aslanidi (2011), Lyócsa, Molnár, Plihal (2019), Weber (2019) and Ehrmann and Talmi (2020), among others, and specifically for the results for Poland see the study by Brzeszczyński and Kutan (2015)).

[7] An interesting paper on the emerging markets, but analysing different types of announcements than the release of monetary policy data, is the work by Kaminsky and Schmukler (2002). They investigated what types of local and neighboring–country news (such as agreements with international organizations and credit rating changes) caused stock market movements during the Asian crisis.

[8] The literature on the importance of central banks' communication has recently expanded also in new directions beyond the traditional investigations of financial markets' reactions, which includes now the analyses of consumers' expectations and their perceptions. For example, Lamla and Vinogradov (2019) investigated the effects of the FED announcement events on perceptions and

expectations of inflation and interest rates in the US. They found that informed consumers tend to have lower perceptions and expectations, higher confidence and also smaller errors in case of perceived inflation. The importance of central banks' monetary policy has also been investigated from the perspective of the risk-taking inclinations. For example, Hussain, Bashir and Bilal (2021) reported, based on their study using the data from China, that loose monetary policy increases bank risk-taking behaviour. Their findings evidence that the bank-specific factors (such as size, liquidity and capitalization) do not significantly affect the risk-taking channel, however the market structure does have a stabilizing effect on the monetary policy transmission and on the level of risk-taking effects.

[9] Another interesting area in this stream of literature, although quite often overlooked in case of emerging markets research, is the analysis of investors' reactions to public announcements in terms of the changes in their activity (see e.g. the study by Brzeszczyński and Kutan (2015), which investigated this issue by using the volume of trade data from the foreign exchange market in Poland derived from the Reuters dealing system for currency trading).

[10] Indices WIG, WIG20 and sWIG80 are listed on the Warsaw Stock Exchange (WSE) and they are most important reference benchmarks for the WSE investors. WIG is a broad market index, WIG20 is a 'blue chip stocks' index of the 20 largest and most liquid companies and sWIG80 is an index of small stocks. By selecting these 3 indices, we are able to measure and compare the market reactions in case of different stock sizes.

[11] The foreign exchange rates are defined as the number of units of the Polish zloty (PLN) per one unit of the foreign currency (USD, EUR, GBP, CHF or JPY).

[12] Given that monetary policy shocks in the global markets may be interlinked with monetary policy decisions in other local markets (see e.g. evidence presented by Igan et al. (2011) relying on the data from the US market and markets in 17 other countries), as a matter of additional robustness check we also estimated versions of all models with alternative control variables that are capable of isolating any possible effects of domestic- from foreign driven monetary policy announcements. We captured the effect of foreign *versus* domestic influences by regressing the global control variables against the respective instrument from our models and by extracting the residuals. In the next step, these residuals were used as an alternative control variable and all models were re-estimated accordingly with it in their new specifications in order to perform further robustness checks. The results are summarised in Tables A1 and A2 in the Appendix.

[13] We estimated also alternative specifications of models under other distributional assumptions than the normal distribution, such as: Student's t-distribution, Student's t-distribution with fixed degrees of freedom, Generalized Error (GED) distribution and also Generalized Error (GED) distribution with fixed parameters. The results were found to be very similar in terms of the value of the estimated parameters and their significance etc. For example, in the first model for 10 years bonds reported in Table 4 the original estimate of the first statistically significant dummy for the RATE_DOWN variable under the normal distribution assumption was: -0.0157 (significant at 5% level), while the estimates under those four alternative distributional assumptions were: -0.0189 (significant at 1% level), -0.0172 (significant at 1% level), -0.0151 (significant at 5% level) and -0.0144 (significant at 5% level), respectively. We can conclude, hence, that these results are qualitatively the same and the change of the distributional assumptions did not have any material effect on them.

[14] The voting reports, which present the Monetary Policy Council members' voting results, were obtained directly from the National Bank of Poland (NBP) and they are available at: https://www.nbp.pl/homen.aspx?f=/en/publikacje/o_polityce_pienieznej/voting.html

[15] Trading costs always differ depending on such factors as size of transactions, trading platforms used by investors or even individual arrangements between the investors as customers and the companies owning / managing the trading platforms, so in reality there is no single trading costs level that can be uniformly adopted for any particular instrument. Therefore, we used in our study a spectrum of different trading costs to illustrate how the presented strategies perform depending on what trading costs are applied. However, we also indicate here what are the 'typical' trading costs in the 3 markets analysed in our paper for round-trip transactions (i.e. buying and selling), which are about 0.4% - 0.6% in the bonds market and about 0.8% - 0.9% in the stock market. In

the foreign exchange market, the trading cost is substantially smaller and it depends mainly on the bid-ask spread, which can widely vary even during one day, but it should be assumed to be on average around 0.02% - 0.05% (also for round-trip transactions). Therefore, for the strategy presented in this paper, which is heavily dominated by bonds, the most typical trading cost to execute it can be assumed to be around 0.5% level. In Figure 3 we further illustrate a variety of results using a broader interval (where 0.5% is positioned in the middle of it) to reflect the situations that some (usually larger) investors can achieve lower trading cost, while for some other (usually smaller) investors the trading cost can be substantially higher. In summary, the graph in Figure 3 depicts the results of the strategy with inclusion of a typical trading cost around the middle of the assumed costs spectrum (i.e. the middle of the horizontal axis titled: 'Transaction costs') and demonstrates how this strategy performs when such typical cost deviates upwards or downwards depending on the value of executed transactions, size of the investors (and their overall volume of trade), method of trading etc.

[16] As additional robustness check, we also tested the models with longer leads and lags, but the statistical significance in these cases was, naturally, diminishing or even completely disappearing. For example, the results for all 3 market segments covering all 12 instruments in models with additional lag $k = -3$ and lead $k = +3$ show that there was an increasingly smaller number of additional instances of statistical significance across all instruments from all market segments. Consistently with all other findings, they were detected more often for the lag ($k = -3$) rather than the lead ($k = +3$) and they were the case most often in bonds market models, while the most influential types of announcements were, once again, interest rates followed by the M3 money supply.

APPENDIX:

Table A1. Number of statistically significant (at p–value: 0.01, 0.05 or 0.10) coefficients' estimates for given instrument and type of announcement from models with alternative control variables

Type of announcement:	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return	SUM:
Interest rate	4	3	7	6	2	2	4	0	2	1	0	1	32
Money supply (M3)	5	0	1	0	0	1	2	1	4	0	0	3	17
Current account	3	0	0	1	1	0	0	1	0	0	0	0	6
Official reserves	1	0	3	2	1	1	0	0	0	2	0	0	10
SUM:	13	3	11	9	4	4	6	2	6	3	0	4	65

Note: Every column presents the numbers of statistically significant estimates for each of 12 equations given by equation (1). Table A1 contains a summary of results for the variants of models with dummy variables with lags and leads spanning from lag -2 to lead +2 with alternative control variables.

Table A2. Number of statistically significant (at p–value: 0.01, 0.05 or 0.10) coefficients' estimates for given instrument and direction of the change in announcement value from models with alternative control variables

Type of change:	10 years bond yield	1 year bond yield	2 years bond yield	5 years bond yield	CHF/PLN exchange rate return	EUR/PLN exchange rate return	GBP/PLN exchange rate return	JPY/PLN exchange rate return	USDPLN exchange rate return	sWIG80 index return	WIG index return	WIG20 index return	SUM:
Increase	3	0	2	2	3	1	0	1	0	0	0	2	14
Decrease	3	1	3	3	1	1	4	0	2	2	0	1	21
Above expectations	2	1	3	1	0	0	1	1	2	0	0	0	11
Below expectations	5	1	3	3	0	2	1	0	2	1	0	1	19
SUM:	13	3	11	9	4	4	6	2	6	3	0	4	65

Note: Every column presents the numbers of statistically significant estimates for each of 12 equations given by equation (1). Table A2 contains a summary of results for the variants of models with dummy variables with lags and leads spanning from lag -2 to lead +2 with alternative control variables.